VOLUME 83 NO. PL3
SEPTEMBER 1957

JOURNAL of the

Pipeline Division

PROCEEDINGS OF THE

AMERICAN SOCIETY OF CIVIL ENGINEERS

BASIC REQUIREMENTS FOR MANUSCRIPTS

This Journal represents an effort by the Society to deliver information to th reader with the greatest possible speed. To this end the material herein ha none of the usual editing required in more formal publications.

Original papers and discussions of current papers should be submitted to th Manager of Technical Publications, ASCE. The final date on which a discussio should reach the Society is given as a footnote with each paper. Those who ar planning to submit material will expedite the review and publication procedure by complying with the following basic requirements:

1. Titles should have a length not exceeding 50 characters and spaces.

2. A 50-word summary should accompany the paper.

3. The manuscript (a ribbon copy and two copies) should be double-space on one side of 8½-in. by 11-in. paper. Papers that were originally prepared fo oral presentation must be rewritten into the third person before being submitte

4. The author's full name, Society membership grade, and footnote referenc stating present employment should appear on the first page of the paper.

5. Mathematics are reproduced directly from the copy that is submitted Because of this, it is necessary that capital letters be drawn, in black ink, 3/16-in high (with all other symbols and characters in the proportions dictated b standard drafting practice) and that no line of mathematics be longer than 6½-in Ribbon copies of typed equations may be used but they will be proportionatel smaller in the printed version.

6. Tables should be typed (ribbon copies) on one side of 8½-in. by 11-in paper within a 6½-in. by 10½-in. invisible frame. Small tables should be groupe within this frame. Specific reference and explanation should be made in the tex for each table.

7. Illustrations should be drawn in black ink on one side of 8½-in. by 11-in paper within an invisible frame that measures 6½-in. by 10½-in.; the captio should also be included within the frame. Because illustrations will be reduce to 69% of the original size, the capital letters should be 3/16-in. high. Photograph should be submitted as glossy prints in a size that is less than 6½-in. by 10½-in Explanations and descriptions should be made within the text for each illustratio

8. Papers should average about 12,000 words in length and should be n longer than 18,000 words. As an approximation, each full page of typed tex table, or illustration is the equivalent of 300 words.

Further information concerning the preparation of technical papers is con tained in the "Technical Publications Handbook" which can be obtained fro the Society.

Reprints from this Journal may be made on condition that the full title o the paper, name of author, page reference (or paper number), and date o publication by the Society are given. The Society is not responsible for an statement made or opinion expressed in its publications.

This Journal is published by the American Society of Civil Engineer Publication office is at 2500 South State Street, Ann Arbor, Michigan. Editori and General Offices are at 33 West 39 Street, New York 18, New York. $4.00 o a member's dues are applied as a subscription to this Journal.

AT,BD,CP,CO,HW,IR,SU,WW,P

Journal of the

PIPELINE DIVISION

Proceedings of the American Society of Civil Engineers

PIPELINE DIVISION
COMMITTEE ON PUBLICATIONS
Herbert A. Smallwood, Chairman

CONTENTS

September, 1957

Papers

	Number
Hydrostatic Testing of Pipelines by Leon E. Brooks	1375
Route Surveys for Offshore Pipelines by Clyde Aldridge	1376
Discussion	1383

DIVISION ACTIVITIES

News 1957-17

Copyright 1957 by the American Society of Civil Engineers.

Paper 1375 September, 1957 PL 3

Journal of the
PIPELINE DIVISION
Proceedings of the American Society of Civil Engineers

HYDROSTATIC TESTING OF PIPE LINES[a]

Leon E. Brooks[1]

SYNOPSIS

Hydrostatic testing of pipelines has become a principal method of testing for the following reasons: (1) Rehabilitation of old systems. (2) Increase in pipelines. (3) Advances in pipe manufacture. (4) Industry Reapproval of current codes. (5) Natural advantages of water testing. To satisfactorily test a line, major importance should be given to properly planning the test, use of proper equipment with emphasis on mobility, and utilization of experienced and qualified personnel.

Hydrostatic testing or "Water Testing" of cross country pipe lines as an accepted practice has been developed by the pipe line industry relatively recently. In the past a line was usually tested with the product to be carried by it, be it gas, oil, or oil products. There have been numerous developments that have caused this method of testing to be replaced with water testing in many cases. In fact it is now common enough throughout the industry that the planning and performing of a water test as will be briefly discussed here, has become a real problem to most companies.

With these problems of course have come benefits and a more concise understanding of these may be obtained by taking a brief look at some of the major developments that have brought about the change to water testing. Some of these are listed below.

1. Rehabilitation of Old System

In all systems after several years of service, failures begin to occur in the line. These failures may be caused from corrosion, defects in the pipe that were not found by the test, and other varied reasons. The older the line usually the more frequent these failures. As the frequency of the failures in a line increased there was the serious problem of eliminating them, or at

Note: Discussion open until February 1, 1958, Paper 1375 is part of the copyrighted Journal of the Pipeline Division of the American Society of Civil Engineers, Vol. 83, No. PL 3, September, 1957.

a. Presented at a meeting of the ASCE at Jackson, Miss., Feb. 18, 1957.

1. Chief Engr., Williams Pressure Service Co., Shreveport, La.

least lowering their frequency, or be faced with serious losses in dollars and good will. One approach to the problem was to lower the pressures at which the line was operated. In the case of corrosion, this was a temporary solution. Where the failures were due to other causes, it was certainly an expensive solution in the long term, due to lost revenue. A more satisfactory approach was the removal, reconditioning, and relaying of certain sections of line with the highest break frequency. There were instances where as much as 100 or more miles of line were relayed. As this problem confronted more and more companies, numerous studies were made to find the most economical solution.

From these came the approach that rather than uncover many hundreds of feet of line, the vast majority of which was good line in no need of repair, if some means could be discovered to find only the bad joints, then only they would have to be replaced. In fact for a line of appreciable length a solution such as this was almost a necessity. From this Hydrostatic Testing as a means of rehabilitating a line was begun. The idea being to select a test pressure sufficiently high that you will break most of the pipe, that would fail during operation in a reasonable length of time, therefore having to replace only the bad pipe. Water was selected as the testing medium since a failure would cause very little damage, and it is available along the route of almost every line. To purposefully break a line was definitely a new line of thought, but is one that is being accepted and utilized by more and more companies every year.

2. Increase in Pipe Lines

The recent years have witnessed a boom in the pipe line industry and this has naturally resulted in a pipe line conscious public. This is emphasized as pipe lines are laid in more and more congested areas or as the congested areas move outward to where lines already exist. As there become more and more lines, resulting in more and more tests, it is inevitable more failures occur during these tests. Due to the areas now crossed by the lines the actual property damage is potentially much greater than previously confronted, and the potential damage to public relations immeasurable. Water testing has been adopted by some to lessen these risks.

3. Advances in Pipe Manufacture

Progress has been made in the development of steel to increase its allowable working pressure for the same diameter and wall thickness pipe by the increase of the minimum yield point of the steel. By raising the working pressure there is potentially more energy stored in the same space. This is especially true in the case of gas, and as pressures have been raised, the potential damage of gas pipeline failure has increased more and more. Gas line breaks of several hundred feet have occurred during gas tests, and this is justification to many for hydrostatically testing the line.

4. Industry Reapproval of Current Codes

During this recent period of rapid development, a few gas transmission line blowouts and distribution system failures, which were of a particularly spectacular nature, drew widespread publicity and public attention. As a result, regulatory bodies in particular became more and more aware of the

importance of safety in the operation of gas transmission and distribution facilities. Several states, including Connecticut, Massachusetts, New York, New Jersey, and Michigan, have set up regulations with respect to design, construction, and operation of gas pipe lines. In addition to this a bill was introduced in the House of Representatives, which proposed to regulate construction of interstate pipelines.

The gas industry was quick to realize that if each of the 48 states promulgated its own rules the industry would be subject to many conflicting and different regulations. In an effort to forestall any such possibility, the American Gas Association requested the American Standards Association to review the piping code then in use, and a sub-committee was established to accomplish this. This sub-committee was known as Sub-Committee 8 of the American Standards Association, Sectional Committee B31-1, Code for Pressure Piping. After many investigations and consideration of voluminous testimony, a new code was adopted. With regard to hydrostatic testing, it was deemed necessary to make it mandatory where the line crossed certain population areas, plants, etc. hydrostatic testing was approved as being acceptable under all conditions. For this reason many companies have adopted hydrostatic testing as standard procedure since there will be no question as to its meeting code requirements.

5. Natural Advantage of Water Testing

Regardless of the reasons discussed previously, there are some companies, and at times probably all companies, that water test some portions of their systems due to the natural advantages of this medium. The most prominent of these advantages is that in most cases water is available along the route of the line. This is especially advantageous in a long transmission line, where gas probably would not be available except at a few points and probably only at one end or the other. This would require the testing program to be wholly dependent on the gas supply, and in case of failure or other difficulties with testing, it could delay the placing of the line in service.

A natural advantage that has become apparent with the development of water testing is its adaptability to yield testing, or the testing of the line to a pressure that will approach the yield point of the steel. This of course allows a line to be tested to much higher pressures than required. Some companies wish to take advantage of this, reasoning that if defective joints of pipe can be removed during the tests, possible operating troubles will be averted. Water is the only medium that can be satisfactorily used for this type testing.

In comparison to a gas or air test, there are two additional advantages that are due to the relatively low compressibility of water. The first being that a very small leak is apparent from a drop in pressure on the gauges in a short period of time. In the case of gas or air a much larger volume loss would be necessary to give a corresponding pressure drop. Secondly, maximum test pressure can be reached in a very short time; in most cases a matter of a very few hours. This allows a line to be placed in service immediately upon completion, or at least a minimum time after completion, which in some cases can bring about savings of thousands of dollars.

Of course this cannot be done without proper selection of men and equipment and proper scheduling of the work. In fact, all of the previously discussed advantages can be overcome and reversed by improper or lack of

planning. There is no more important phase of a testing program. Too often a company will spend many thousands of dollars carefully planning the construction of a pipe line, thousands more constructing this line, with the grading, ditching, welding and laying operations being diligently inspected, only to test it as an after thought.

The first step in formulating the plans is to prepare a schematic diagram showing the entire line to be tested, the sections to be laid by separate contractors, and the direction in which these sections will be laid. Main line valve locations and stations should be shown. This is the basic diagram from which the testing schedule must be developed.

There are two preliminary surveys that must be made before beginning on the details of the plan itself, as they affect practically all other phases of the plan and should be investigated. The first a terrain survey, of a very general nature, to determine the necessity of plotting a profile of the line. This may be done by use of available topographic maps to see generally if changes in elevation might cause a pressure differential larger than the desired difference between the maximum and minimum pressures. Sometimes this can be ascertained by flying the route of the line. Using the planes altimeter to judge the approximate height of doubtful spots. Such a survey may determine that a profile of one section of line is not necessary and other sections are, or that a more detailed investigation is necessary.

If it is deemed necessary to have a profile of the line, work should begin immediately while other plans are being formulated. In fact, many of the plans will depend largely upon the profile. In some cases it may be desirable to plot a preliminary profile from standard aerial maps so as to know what to expect. The most inexpensive method to profile a line is by plotting elevations taken from government quadrangle sheets. This type of profile has been proved to be sufficiently accurate, but in many areas these sheets are not available and levels may have to be run. A method of profiling that is more economical and expedient than running levels is utilizing aneroid barometers. By this method a barometer is placed at a bench mark of known elevation, and other barometers are placed at selected points along the line where readings are to be taken. These points being visual "highs" and "lows" and other critical points such as values, manifolds, streams. Either by use of two way radio, or by taking a series of readings at known time intervals, an accurate profile of the line can be plotted. From this allowable differential manifold locations are selected.

The second preliminary survey necessary is a water survey. The principal purpose of this being to determine what water sources are available along the route of the pipe line and to determine their desirability. First consideration is given to the location of the water source as related to construction. The closer it is to the beginning of the construction job, the quicker the testing may start, or at least the scheduling of the testing can be decided by other factors. Some of these other factors which are weighed before the final selection is made are:

(1) Access. It will be necessary to carry fuel, men, and equipment in and out of a location many times.

(2) Quantity of Water. There must be plenty of water to run the pumps continuously and it should be ascertained if it is necessary to build reservoirs or dams to insure this.

(3) Cost. Other factors being equal, the cost of the water is considered, although normally this is a relatively minor item.

After a water source has been selected, or more likely several desirable sources are tentatively selected with a final selection to be made later, a chemical analysis of each should be made to determine the corrosive qualities of the water. This analysis should include the pH, total alkalinity, occluded CO_2 and chlorides. If this analysis shows that the water, if left in the line for a two-three month period would be detrimental, then the water should be treated to overcome this.

After this preliminary work has been completed, the equipment and personnel may be selected. In selection of this equipment, the testing operation should be considered as consisting of two separate operations—filling and pressuring. The principal consideration for filling the line is of course volume, however this is limited by other factors. Experience has shown that for best results the fill pump selected should have a rated capacity sufficient to fill a line at a minimum rate of 1 mile per three hours, and a velocity of 1 mile per hour is better. It has been found that if the scraper in front of the water moves slower than this, it will frequently stop, permitting water to bypass it. This will cause numerous troubles later when the scraper is received at the end of the line and will permit the entry of air to the line. In 30" pipe and smaller, a pump capacity of approximately 1000 gpm is satisfactory.

If the fill pump must pump over hills and mountains it must be capable of overcoming pressures due to hydrostatic head, as determined from the profile of the line. The fill equipment should be relatively mobile or portable. In order to meet the above requirements of volume, head, and mobility, and being limited by engines available with sufficient horsepower for such a pump, it has been found desirable to have two units to a fill unit. The first of these consisting of a Lo-Head Pump, 6 inches in size, of a jet or centrifugal type and powered by a standard industrial gasoline or small diesel engine. It should have a capacity of approximately 1000 gpm at a discharge pressure of approximately 100 psi. This unit can be transported on a 1 ton pick-up truck, and is easily handled by a "gin" pole truck, making it relatively easy to set at the water source. The main fill pump consists of a 6-inch three-stage centrifugal pump driven by twin 6-cylinder diesel engines. The capacity of this pump is 1050 gpm at 350 psi pressure. This pump is mounted on a Lo-Boy trailer together with a light plant, 500 gallon fuel tank, and 500 feet of 6" light weight, quick-coupled fill pipe. Using the two pumps in series gives a very desirable unit capable of approximately 1000 gpm at 450 psi discharge pressure.

During the filling operation a flow meter is very useful. It should be of a type that totalizes the volume pumped and indicates the rate of fill in gpm. On long fills it is sometimes desirable to install a pressure recorder on the line near the pump to serve as a check of heads encountered. When correlated with the profile this will give an indication of progress during the fill, and serves as a log after completion of the test.

Emphasis should be placed on mobility in the selection of a pressure unit. In a testing program of any magnitude the pressure unit is moved often, and in the case of a rehabilitation test sometimes it may be moved 4 or more times in one day. The pump should be a positive action or reciprocating type pump in order to insure proper control of the test. A pump permanently mounted on a truck with either an auxillary engine or a power take-off from the truck engine is satisfactory. The pump drive should be of variable speed, so that in lower pressure ranges a maximum output can be obtained. As the

test pressure is neared the pump can be slowed, eliminating surges and insuring that the test pressure will not be exceeded. A water storage tank of at least 500 gallon capacity should be mounted on the truck. This gives a storage space of sufficient quantity to furnish suction water for repressuring a section should two adjoining sections be under test at once, or in the case water to pressure with is not available at the pressure point. All connections that must be disassembled when the truck is moved should be quick coupling, and high pressure hose of chicksan joints should be used so that no "fits" are necessary, in connecting the pipe.

A complete set of gauges including an indicating gauge, recording gauge, and dead weight gauge should be used for the pressuring operation. Emphasis is placed on the use of a dead weight gauge. No test should be conducted without one, because it is very easy for a dial gauge or recorder to be in error due to the normal handling of a testing program. This may cause a test pressure to be exceeded or not to be reached. In any case the test will not be conclusive. Also, with a dead weight gauge, a minute leak is discernable due to the accuracy to which it can be read.

The selection of the proper equipment may be useless unless there is a proper selection of personnel. Probably most important is the assignment of one person to the complete control of the testing program. He is responsible for the movement of pumps, the carrying out the testing schedule, and should have more than a working knowledge of hydraulics. In this way many every day problems that arise with the pumping of water across country may be met satisfactorily. In addition to an overall supervisor an engineer trained in testing should be located at each point where filling and pressuring operations are conducted. He should make spot decisions that arise on the job, and should maintain the records. It is desirable for all of the personnel performing the test, the fill pump operators, pressure truck operators, engineers and the men catching the "pigs" to be experienced in hydrostatic testing. To illustrate this, note that usually some water reaches a given point before the "pig". This may be construction water or water that may have by-passed the "pig". Should the man catching the pig be inexperienced, he may become confused and close the valve too soon, or not soon enough. This could cause trouble later either in pressuring or in cleaning the line. An experienced man on the pumps can tell exactly what is going on further down the line by watching the discharge pressure gauge. He can tell when the pressure truck is pressuring a section or moving to another section. During the fill he can ascertain when the "pig" is going over a certain hill or passing other check points along the line. This takes on added significance when the position of the "pig" may be 50 to 100 miles from the location of the pumps.

In order to determine the amount of equipment and personnel required for a particular job, a testing time schedule must be set up, with the first consideration being given to the construction schedule and total length of the job. The ultimate goal of a schedule is to allow the test to be completed and the line placed in service in a minimum time after completion of construction. If a line is relatively short, the test will probably not commence until the entire job is complete. However, in long jobs and especially a job utilizing more than one contractor, it is advantageous to begin testing much sooner. The location of available water sources will control, to a great extent, the time at which testing can begin, and the total number of testing "units"

required. This portion of the testing plan will undoubtedly have to be altered from time to time to fit actual construction conditions. One of the chief causes for disruption of testing schedules is the occurrence of an abnormal number of failures in a line. In view of this a section of pipe for a particular manufacturer should be tested as soon as practical to determine an expected break frequency.

The fill sections, or sections filled from one water source, are determined by the location of water sources and construction progress. In most cases it would not be desirable to test all of a section filled from one point at the same time. In many cases this is not possible. In hilly and mountainous terrain a minimum and maximum pressure must be selected and this differential limits the length of a test section. At critical points where this differential will be exceeded, a manifold must be installed to isolate the section. There are times when main line block valves can be utilized to eliminate one or more of these manifolds, and it is good practice to use these valves to isolate sections even though a manifold may not be required by reason of elevation. There is a great temptation, in flat country, to test extremely long sections. This has been proven undesirable. Although it may eliminate several hold periods, if the section is too long, control is lost. The larger the pipe diameter the more this holds true. There is a definite "settling out" period after maximum pressure has been reached. The length of time required for this depends upon total volume of water involved, speed of the pressuring operation, temperature (both that of the ground and water put in the pipe), amount of exposed pipe, air in the line, and numerous other conditions that must be evaluated in the field. Normally this period is a matter of a few minutes, but sometimes it is as long as 24 hours or more.

In the case of a new line the minimum pressure to which any pipe will be tested is usually determined by a code or regulation. In the case of Natural Gas Transmission Lines this is the ASA Code for pressure piping.

In the case of rehabilitation of an old line, it may be based on a known pressure reversal. There are records that show that within a short time after testing a line, and for no apparent reason, it has failed at a pressure 525 psi less than the test pressure.

It is sometimes desirable to select a minimum pressure higher than that required by the code in order to give a greater known safety factor. This may be especially true in a case where breaks have indicated that an appreciable percentage of the pipe did not fulfill the specifications with regards to strength requirements and would be operating at a safety factor somewhat less than designed.

The selection of a maximum pressure is usually insignificant in flat country, but maximum pressure must be selected in cases where there is an appreciable elevation difference. This maximum is usually set as a certain percentage of specified minimum yield, depending upon policies of a particular company. In some cases this maximum has been set as a pressure giving an indication of actual yield, as determined by the plotting of a yield curve in the field. This allows advantage to be taken of the fact that the actual yield point of the pipe is appreciably higher than the specified minimum. Preliminary pressure may be selected by study of the mill test reports of the pipe, then a more exact pressure selected by trial tests of a few sections. The secondary stresses set up in a line cause the yield point, as determined by plotting the internal pressure curve, to vary to such an extent that the only conclusive data must be from actual tests of the line.

At a time that is fully dependent upon construction progress, the actual testing begins. Before the pumps can be set up, certain work must be performed to ready the section of line to be tested. This includes installation of a connection on the line at or near the water source. This connection may be a 6-inch flanged stub on the line to which a 6-inch valve can be connected. A "pig" consisting of 4, 5, or 6 rubber cups should be placed in the line to be pushed ahead of the water. These displacement pigs remove the air from the line ahead of the water, and clean construction debris, such as skids, welding rods, and sand, out of the line. If it is desirable to fill in both directions from a fill point, but in only one direction at the start of the test, a by-pass type manifold may be installed with a tee between two valves in the by-pass. This will allow the fill to be made in one or the other direction at any time. The by-pass manifolds required by elevation difference are installed in the line with a pig placed ahead of each. A weld cap or temporary scraper trap is attached to the end of the section to be filled.

The Lo-Head Pump is set up at the water source and discharges through a quick coupled 6-inch line to the suction side of the fill pump, which in turn discharges into the line. Air is bled off through main line blow-off's or bleeders provided on the manifolds ahead of the water. Construction water and other water ahead of the pig is also bled off and the fill is considered complete when the pigs are bled into the manifolds and temporary scraper trap. If this is not done a satisfactory test can be completed however, although the results may not be as conclusive due to the presence of excessive air and the plugging effect of the scraper.

After the line has been filled and fill pump pressure applied to the line, the line is then isolated into test sections and pressured. The pump is set up at a previously selected point along the line and high pressure chicksan joints are connected between an outlet on the discharge side of the pressure pump and an outlet on the pipeline. Suction is taken from the storage tank which is usually filled by taking water from a section back of the one being pressurized. If the maximum pressure is below the mill test point of the pipe, accepted practice is to pressure the section directly to test pressure, slowing the pump approximately 30 psi below maximum to prevent surges. It is a good rule that should this pressure exceed 1000 psi, pressuring should stop at this point and a leak test of approximately 30 minutes duration be taken. Dead weight readings should be taken at 5 minute intervals. This will indicate any major leaks, such as gaskets, screw connection, etc., that need to be stopped before a test can be completed. Dead weight readings 2 psi intervals should be made for the last 50 psi under maximum.

If the maximum pressure to be reached at any point on the line exceeds the Mill Test of the pipe, then the pump should be stopped when the pressure reaches this point and a leak test taken. Accepted practice is to plot a "yield curve" when pressuring beyond this point. This curve is a graph with the strokes of the pump (quantity of water injected into the pipe) as the abscissa and the pounds of pressure as the ordinate. Under normal conditions this curve will be a straight line. It will deviate from a straight line when it approaches the yield point of the pipe or in some cases if a leak begins to open up. If a deviation occurs before desired maximum is reached the pump may be stopped, a short leak test held, and pressuring continued or lowered by bleeding. The line is pressured until the maximum is reached or a second deviation occurs. If the first deviation was not due to a leak, the second pressuring will result in a straight line for several psi above the first due to the steel having been cold worked.

After reaching a maximum test pressure, the pressure is then held for a period of time. The length of this holding period is arbitrary except under certain conditions where a regulatory body or code requires a 24 hour test.

After giving consideration to the overall time schedule, where a large number of test sections exist, a test of less than 24 hours may be advantageous, or even necessary for the testing program to be completed on schedule. This also is true if there are an undue number of pipe failures, or other delays such as climatic conditions, material shortage, and/or work stoppages. If a section indicates a leak exists, then of course, the test should be held for a sufficient time to locate this leak or to at least obtain a strength test.

As mentioned before there is usually a pressure drop at the beginning of every test and some pressure drop may continue for a period exceeding 24 hours, without their being any leak in the line. This necessitates the adoption of an acceptable leak rate, which rate varies with each job, depending in part on season, pipe size, water source, length of section, and length of test. Where a shorter hold period than 24 hours is accepted, several "typical" sections should be held for sufficient time to allow the pressure drop to cease. Data as to the performance of the test prior to the accepted "hold" period is used as a basis for an acceptable pressure drop. The pressure drop should be expressed in gallons of water as well as pounds per square inch for evaluation of the possibility and size of a leak since the volume of water represented by a given pressure drop will vary directly with the length of the section.

After acceptance of a test, the water must be removed from the line. This is accomplished by pushing one or more "pigs" through the line with gas or compressed air. When using compressed air on a line of any size or hilly terrain, an adjoining section should be isolated and used as a storage bottle for the air, so that sufficient volumes and pressures are made available to give a continuous run. The number of scrapers to be run may vary with each particular job. The use of a slug of alcohol after the initial water removal is being used by more and more companies to aid in "drying" the line, and to prevent freeze ups by liquids left in the line immediately after a test. These liquids adhere to the walls of the pipe and collect to some extent in low spots along the line. The procedure used with variations is generally as follows: Remove the major part of the water with a "pig" and follow by running 3 or 4 additional "pigs". Drain any known recesses that cannot be cleared with a pig, such as the lower chamber of full opening valves. Push a slug of alcohol through the line between two pigs. The alcohol-water solution drained from the far end of a section should be analyzed as to volume recovered and alcohol content. The volume recovered should be approximately that put in at the start. If it is only a fraction of this, more scrapers should be run. If methonal is used for the initial slug, the amount of methonal used should be approximately the amount of water left in the line after pigging. Past runs indicate that after pigging as described above, approximately 3 barrels of water per mile of 30 pipe remains on the walls of the pipe. If the concentration of the methonal water solution is high enough this solution may be used as the "slug" on adjacent sections.

Hydrostatic testing as discussed here varies in effort and cost with terrain, weather and availability of water. With proper planning and engineering the cost and effort under adverse conditions can be minimized.

When testing in mountainous terrain there are many problems that discourage hydrostatic testing. One of these being the numerous test sections required due to differential heads. Although these require numerous hold periods to test each one separately, it is often possible to test two sections of approximately the same maximum and minimum elevation at the same time. When these are separated by a section of higher elevation it may be possible to test from the low end of one of the two sections through the higher section. This same principle can be utilized in testing sections at lower elevations with both ends of the section relatively inaccessible, by testing through a section of higher elevation with a more accessible pressure point. Another problem often encountered is that the heads exceed the limits of one fill pump. This may be overcome by compounding two or more pumps at the water source, or placing a fill pump at a by-pass manifold of desired elevation and, by closing the manifold valve using it as a booster pump.

In testing during extreme cold weather, the prime difficulty is the danger of exposed pipe and valves freezing. All possible installation should be backfilled and, in case of extreme freezing, exposed installations can be protected by covering with tarps and heating with flares or pots. Alcohol can be mixed with the water used to pressure, protecting the pump as well as installation at the pressure point. This also protects the gauge lines, preventing a freeze up, and false readings of the gauges. The water should be removed from the line as soon as possible following the test.

In drought areas the problem, of course, is water. Sources can usually be found at some point along the line, which often times causes an exceptionally long fill, but this can properly be compensated for in the overall testing program by proper planning. If no water is available at all along the route, it can be hauled to fill the line. This has proved satisfactory in cases involving small diameter, or short lines.

Where available water in its natural state is undesirable, usually treatment can overcome this. In the case of undue sludge and foreign matter, the water can be filtered. Where the pH is low, this can be raised by treating with soda ash. Recently salt water (Bay water off the Gulf of Mexico) has been used to fill with and its corrosive potential overcome by treating the water with Kontol as recommended by Tretolite Corporation of St. Louis, Missouri.

In conclusion, it is stressed that to satisfactorily test a line, major importance should be given to properly planning the test, use of proper equipment with emphasis on mobility, and utilization of experienced and qualified personnel. Detailed records should be kept and compiled to aid in answering future problems that may arise. There are many problems that have not been solved perfectly and many more will be confronted, that have not been solved at all. With members of the industry seeking solutions and improvements, they will be found and all will reap the benefits.

Paper 1376 September, 1957 PL 3

Journal of the

PIPELINE DIVISION

Proceedings of the American Society of Civil Engineers

ROUTE SURVEYS FOR OFFSHORE PIPELINES[a]

Clyde Aldridge,[1] J.M. ASCE

(Proc. Paper 1376)

SYNOPSIS

Route surveys for Offshore Pipelines present some problems not normally associated with route surveys on land. This paper reviews some of their problems and the equipment and methods used on a 12 pipeline laid offshore of the coast of Louisiana.

First discovery of oil by the Magnolia Petroleum Company in the Eugene Island area off the coast of Louisiana was in 1950.

Initial movement of oil to shore was by barge, then, as production increased, by small tankers. Both proved unreliable due to their inability to load oil from the platforms in bad weather. Since the cost of building ample offshore storage was prohibitive, attention was turned to the possibility of building a marine pipelline. Between the years of 1952 and 1954, a number of studies were made to determine the practicability of off-shore production gathering facilities with a pipe line to shore. These studies indicated such an operation was feasible although there was little precedent to work with.

Investigation for the actual location of the line began in July of 1954. Normal land surveying methods had to be adapted to fit our need in the Gulf.

Preliminary scouting of the shore area near Burns, to find a route through the Texas Company bases in the East Cote Blanche Bay, was done by boat. All structures, visible reefs, channels, etc., were plotted on a U. S. Government Hydrographic Chart. From this data, a possible route was selected through the East Cote Blanche Bay. The remainder of the route from the Pt. Au Fer reef South to Block 51 and thence to Block 126 was selected as a straight line. Actually the entire route was a straight line with the exception of one necessary angle point near shore. Few problems had arisen to this point, but transferring this proposed line to an actual location presented a number of problems. Our first step was to transfer all accumulated data onto a map based on the Lambert conformal conic projection.

Note: Discussion open until February 1, 1958. Paper 1376 is part of the copyrighted Journal of the Pipeline Division of the American Society of Civil Engineers, Vol. 83, No. PL 3, September, 1957.

a. Presented at a meeting of the ASCE at Dallas, Tex., Feb. 16, 1956.

1. Asst. Chf. Engr., Mid-Continent Pipeline Co., Tulsa, Okla.

The locations of the Magnolia platforms were already on this projection, but it was necessary to transfer the locations of the Texas Company platforms to it. This involved some triangulation from shore stations of the U. S. Coast and Geodetic Survey.

Lamber Coordinates for all platforms in the vicinity of the line were determined. Lambert bearings and distances for the proposed line were then determined. We were now ready to "stake" the pipe line.

In the East Cote Blanche Bay area, it was necessary to build only one 15 foot wooden transit tower. Texas Company platforms were sufficiently close to our line to serve for the remainder of the necessary transit stations. Using these transit stations, points at 2 mile intervals through the bay area were located and 40 foot wooden pilings were driven to mark the line location. Intermediate locations could then be made by eye. This procedure was followed on the first 12 miles of line. The remaining 13 miles to Platform 51 was marked by light weight buoys. A transit man on Platform 51 kept the buoy-laying boat on course by radio contact, the buoys being laid as often as necessary to establish a line that was visible to the eye.

The 22 miles between Block 51 and Block 126 was marked in like manner.

Exact stationing of the 40 foot piles were known by triangulation. Approximate stationing of the buoys were determined by sextant. Since the buoys were used only in the open waters of the Gulf, this approximate stationing was sufficient for the preliminary survey.

The location completed, a thorough investigation of the water depths, location of reefs, and soil conditions began.

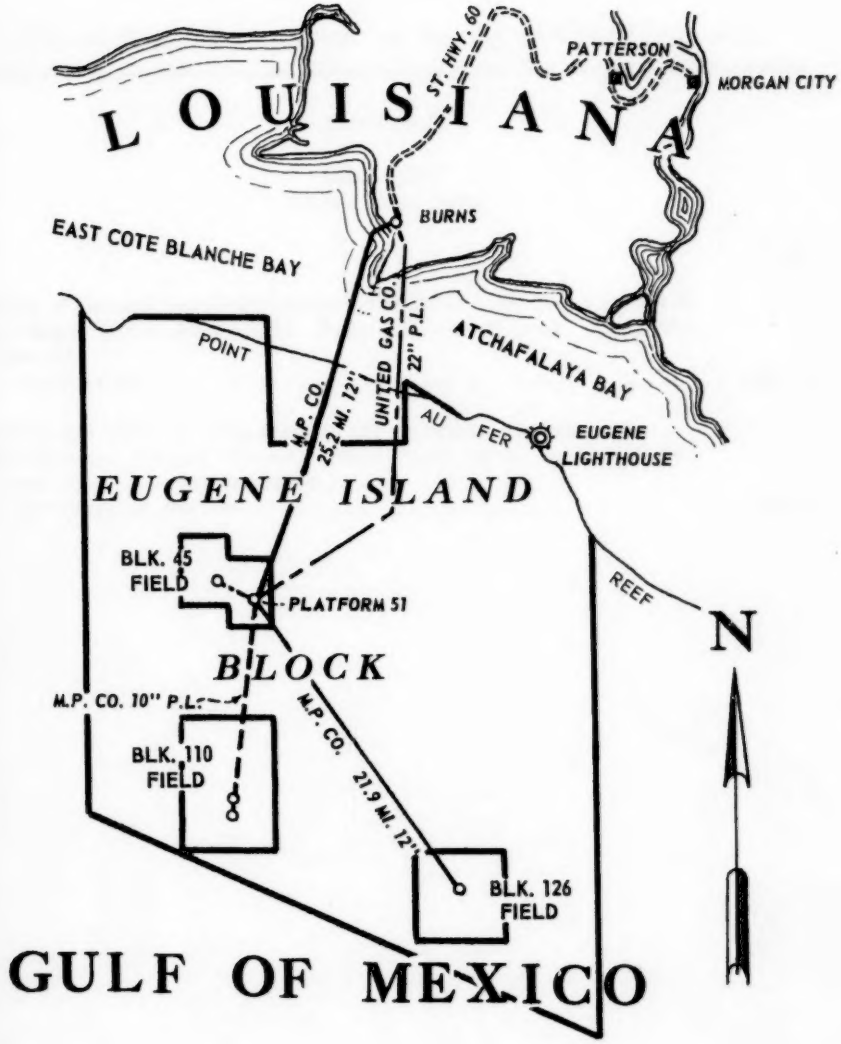
The water depth and location of reefs was accomplished with the use of a portable fathometer. By making a minimum of two runs in opposite directions and maintaining a constant boat speed, a profile of the ocean bottom was made. The error in stationing on this profile was not in excess of 50 feet. The fathometer chart was interpreted and a number of spots were marked for cores and soil samples to be taken. These spots were investigated and marked by large balloons in order that they be triangulated in and accurately located.

This procedure was followed along the entire line until sufficient data was available to draw an accurate profile of the bottom and the first 5 feet of soil. Additional data was available to us from 5 feet to 35 feet below the ocean floor, by the use of a low frequency fathometer (Magnolia Sub Strata Acoustic Probe) before the job was completed. This instrument also verified the data obtained by the Portable Fathometer and soil cores.

No unusual conditions were encountered except the presence of the reefs throughout the bay and a large stump field for the first 3 miles of shore.

Since future location of a marine pipe line can be a very expensive process if its exact location is not known, accurate control of the location of the line was maintained at all times during construction, both by transits on the various platforms and on the laying barges.

Checks were made at random points along the route after the line was completed. The maximum deviation from the proposed location was 10 feet, the remainder of the check points were less than 10 feet.


LOUISIANA
ST. HWY. 60
PATTERSON
MORGAN CITY
BURNS
EAST COTE BLANCHE BAY
POINT
M.P. CO. 25.2 MI. 12"
UNITED GAS CO. 22" P.L.
ATCHAFALAYA BAY
AU
FER
EUGENE LIGHTHOUSE
EUGENE ISLAND
BLK. 45 FIELD
PLATFORM 51
REEF
N
BLOCK
M.P. CO. 10" P.L.
M.P. CO. 21.9 MI. 12"
BLK. 110 FIELD
BLK. 126 FIELD
GULF OF MEXICO

Paper 1383 September, 1957 PL 3

Journal of the

PIPELINE DIVISION

Proceedings of the American Society of Civil Engineers

CONTENTS

DISCUSSION
(Proc. Paper 1383)

Page

Flow of Natural Gas in Pipelines, by William T. Ivey and James H. Dorough. (Proc. Paper 1194. Prior discussion: none. Discussion closed.)
Corrections 1383-3

Prediction of Surge Pressures in Oil Pipelines, by Robert O. Kersten and Edwin J. Waller. (Proc. Paper 1195. Prior discussion: none. Discussion closed.)
by Henry M. Paynter 1383-5

Note: Paper 1383 is part of the copyrighted Journal of the Pipeline Division of the American Society of Civil Engineers, Vol. 83, PL 3, September, 1957.

Discussion of
"FLOW OF NATURAL GAS IN PIPELINES"

by William T. Ivey and James H. Dorough
(Proc. Paper 1194)

CORRECTIONS.—In the running heads on pages 9 through 27 the name Borough should be changed to Dorough. On page 27 the reference to equation (26) should be changed to equation (27) on the next-to-last line of text. On page 28, in lines 1 and 9, the references to Equation 26 should be changed to Equation 27.

Discussion of
"PREDICTION OF SURGE PRESSURES IN OIL PIPELINES"

by Robert D. Kersten and Edwin J. Waller
(Proc. Paper 1195)

HENRY M. PAYNTER,[1] J.M. ASCE.—This writer was considerably impressed and exhilarated in witnessing the penetration of electrical concepts into pipeline engineering to the extent manifested by the excellent paper of Messrs. Kersten and Waller.

However, in the light of such statements of the authors as:

> "The recognition of the electrical analogy permits the formulation of a method of hydraulic circuit analysis similar in many respects to electric circuit analysis."

and again:

> "The basic theme of this entire research activity is the hydraulic-electric analogy. This being the case, electronic computor techniques could be applied and would greatly facilitate the preparation of much of the material in chart and graph form."

it was with considerable shock and surprise to find no mention of the work of this writer, particularly that which appeared in the journals of this same society,[2] and, coincidentally, was first presented in the same city of Jackson, Mississippi over six years earlier in November, 1950.

Presented in this paper were the basic equations corresponding to the authors' equations (1) and (2) and (18) and (19). These were obtained by direct analogy to the corresponding well established electrical equations. However, any interested reader can readily look back to this paper for himself.

There does not seem much point in dwelling further on what in all probability is a simple oversight on the part of the authors; it would seem more appropriate to make only constructive contributions to the pioneering efforts of the present paper.

The principal activities of the writer for over ten years have been concerned with the application of mathematical models and electronic computors to the rational analysis of complex engineering systems. No small part of this endeavor has involved fluid systems such as encountered in pumping stations, pipelines, chemical processes and hydroelectric plants. Without exception, these efforts have been of economic consequence so that the writer feels that he can lend considerable support to the authors' anticipations and hopes for the methods of analysis that they are promulgating.

1. Asst. Prof. of Mech. Eng., Massachusetts Inst. of Technology, Cambridge 39, Mass. President, Pi-Square Eng. Co., Inc., Boston 16, Mass.
2. "Electrical Analogies and Electronic Computers: Surge and Water Hammer Problems," by H. M. Paynter. First Published: August 1952, as ASCE Proceedings-Separate No. 146.

Particularly, in order to expedite the application of computing machinery to pipeline problems, it is worthwhile to discuss several aspects of the present paper in the light of simplifications in analysis and possible computor representations. Two recent publications of the writer would be of help in this connection.[3,4]

Corresponding to the schematic and circuit diagrams in Figure 3 of the paper we may consider the causal block diagrams of Figure 1 of this discussion. Here, there is no longer any necessary restriction to linearity in the analysis and the same diagram can serve both for transient and for steady-state behavior. Note that in Figure 1 (a) the instantaneous power (or energy flow) is measured by the product of the corresponding pair of vaiables, thus:

Mechanical Power Input $\mathbb{P}m = M(t) \cdot N(t)$

Sending End Fluid Power $\mathbb{P}s = Ps(t) \cdot Qs(t)$

Receiving End Fluid Power $\mathbb{P}r = Pr(t) \cdot Qr(t)$

We may conceive, then, of the basic fluid transportation problem in terms of three basic energy transfer operations as indicated, namely:

1. TRANDUCTION in the pumps
2. TRANSMISSION in the pipeline
3. STORAGE in the tanks

All of these components can be represented for analysis and computation such that all significant physical phenomena are taken into account. Moreover, it is not apriori necessary to conduct elaborate experiments to establish the parameters and constants for such representations. Almost without exception these are directly obtained from mechanical fundamentals of manufacturers' test and rating data.

For example, in chosing to represent the reciprocating positive displacement pumps as volumetric sources, as in the authors' Figure 3(b) and (c) and writer's Figure 1(c) and (d), it is clear that several physical facts must be taken into account, as follows:

1. The actual pump output cannot be independent of the connected prime mover characteristics. Thus for any given instantaneous flow, Q_S, as the pressure, P_S, changes so, too, must the torque, M_P, and speed, N, necessarily change.

2. Thus, in the equivalent representation of the reciprocating pumps as volumetric sources delivering a nominal $Q_g(t)$ corresponding to a nominal constant effective speed $N_e(t)$ allowance must be made of at least the following known effects in the representation of the effective internal impedance (the authors' Zi):

   a) Static Operating Characteristics:
      I Prime Mover Torgue-Speed Characteristic
      II Pump Pressure-Flow-Speed Characteristic

3. "A Palimpsest on the Electronic Analog Art" (book) Edited by H. M. Paynter, G. A. Philbrick Researches, Inc. Boston, 1955.
4. "Computer Representations of Engineering Systems Involving Fluid Transients" by F. D. Ezekiel and H. M. Paynter, ASME Paper No. 56-A-120, November, 1956.

b) Dynamic Impedances
I Drive Shaft Elasticity
II Rotary Mechanical Inertia
III Fluid Compressibility in Pump Passages
IV Fluid Inertia in Pump Passages

3. By use of straightforward mathematical, circuit, or block diagram techniques these effects can all be reduced and transferred to the fluid side into an effective source internal impedance Zi but only for the case of sufficiently small changes in variables such that linearity in all elements can be assumed.

4. In the more general (and frequently more important) case of large, nonlinear changes only a diagram such as Figure 1(a) will predict results with any reliability.

It is well worth mentioning the above factors, both to avoid many disappointments in future work and to correct the possible impression that experiments are mandatory before proceeding with computor studies for engineering design and operation.

Let us now consider a possible computor representation corresponding to a block diagram such as that given in Figure 1(c) of the discussion. This is indicated in Figure 2, taking into account the following factors:

1. Constant effective speed of pump, N_e
2. Nominal Crank-Angle-Volume Characteristic of pump, Φ_{av}
3. Pump leakage conductance characteristic, Φ_g
4. Pump mean effective capacitance, C_p

In this last case, it may be desired to account for changes in the capacitance C_p as indicated. Definition of the basic computing operations are given; more details are given in the reference cited.[5] Note that it is not necessary to compute the harmoics since these are automatically generated through Φ_{av}.

Many more (and less) complex models may be constructed without limit, but perhaps this indicates that some satisfactory representation may always be constructed for computing purposes.

The second principal problem concerns the representation of the pipeline transmission elements. A most elegant and practical solution for computing purposes has recently been presented.[4,5] This is based on the assumption that any general variable section pipeline can always be represented by a finite set of differing but uniform, dissipationless transmitters each separated by lumped linear or nonlinear resistances in the form of friction joints. In practical instances, such as those of the present paper, only a few such sections are required for each pipe of the system as indicated in Figure 3. The full justification for such approximations is to be presented in a forthcoming paper.[6]

5. "Circuits and Block Diagrams: Dissipationless Transmission System" by F. D. Ezekiel and H. M. Paynter in The Lightning Empiricist, G. A. Philbrick Researches Inc., Boston, Mass., October, 1956.
6. "Water Hammer in Nonuniform Pipes as an Example of Wave Propogation in Gradually Varying Media" by H. M. Paynter and F. D. Ezekiel, Manuscript of Paper to be presented at Annual Meeting of ASME, November, 1957.

This concentrates interest in the representation of a single length of frictionless pipe. This problem is treated at length in the reference cited[4] and may be summarized in the universal block diagram of Figure 4. For the flow of liquids, the travel times, $T\alpha$ and $T\beta$, for elastic waves upstream and downstream are essentially identical, that is $T\alpha \cong T\beta$. One should note that this is not generally true for gas flow in long pipes.

In the special case of a single frictionless pipe terminating in a large tank or reservoir at constant pressure ($P_r = 0$) and where the downstream flow, Q_r, is not required, the greatly simplified diagram of Figure 5 is applicable.

Thus the type of pipeline design problem of interest to the authors might be studied on a computor representation of the sort indicated in Figure 6. This permits the determination of pressures and flows at two intermediate points in a pipeline. Moreover all problems of design and operation may be studied on the same model, since both static and dynamic behavior are represented at one and the same time. This type of model has frequently been used by the writer for consulting problems, and is therefore, of course, commercially available and accessible.

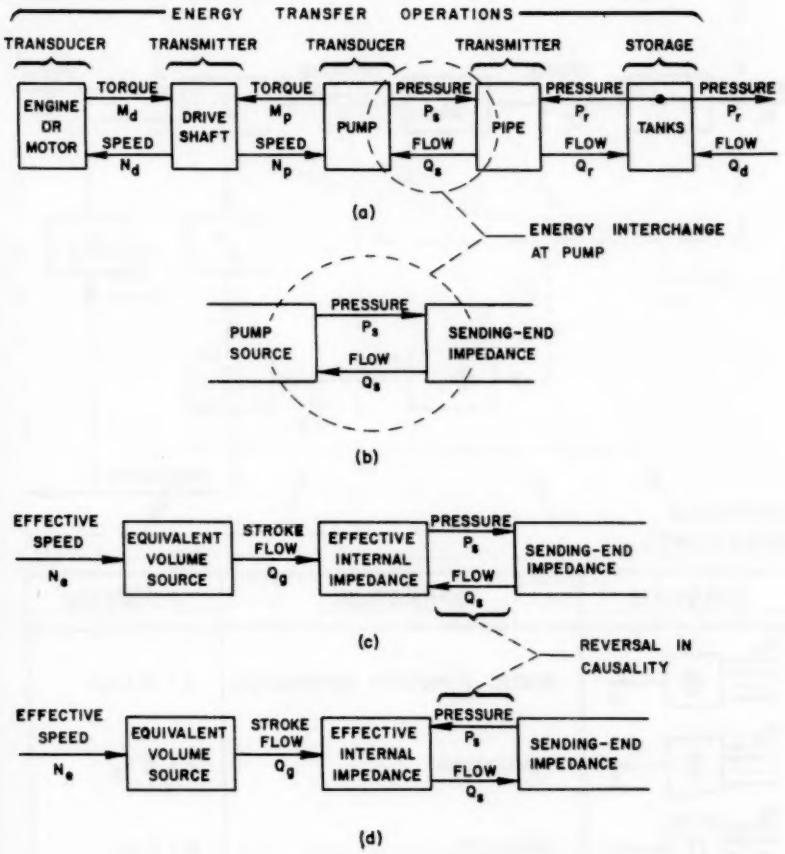
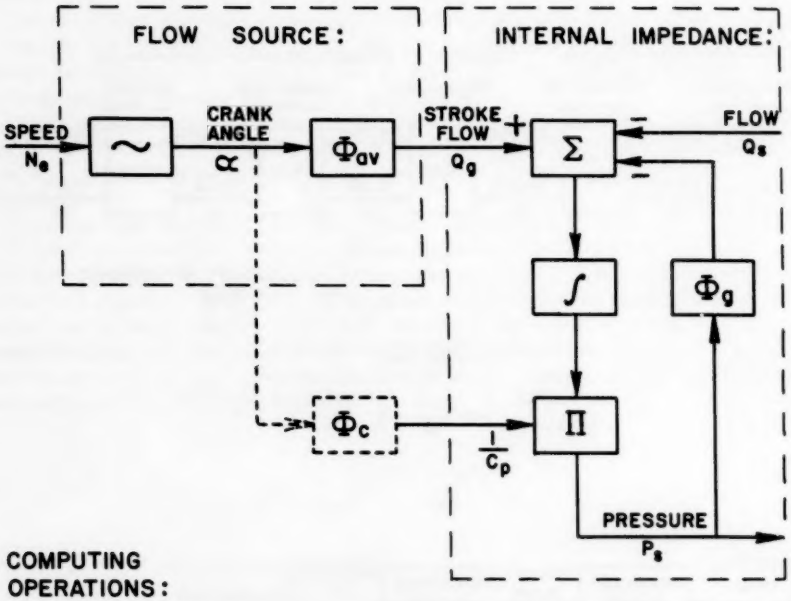


Figure 1: PUMPING SYSTEM BLOCK DIAGRAMS



COMPUTING OPERATIONS:

DIAGRAM	OPERATION	EQUATION
x_k → Φ → y	STATIC FUNCTION GENERATION	$y = \Phi(x_k)$
x_k → Σ → y	SUMMATION	$y = \sum_k x_k$
x_k → Π → y	PRODUCT	$y = \prod_k x_k$
x → $\int$ → y	TEMPORAL INTEGRATION	$y = \int x\,dt$
x → $\sim$ → y	SINUSOIDAL OSCILLATION	$y = \sin(2\pi x t)$

Figure 2: COMPUTOR MODEL of PUMP

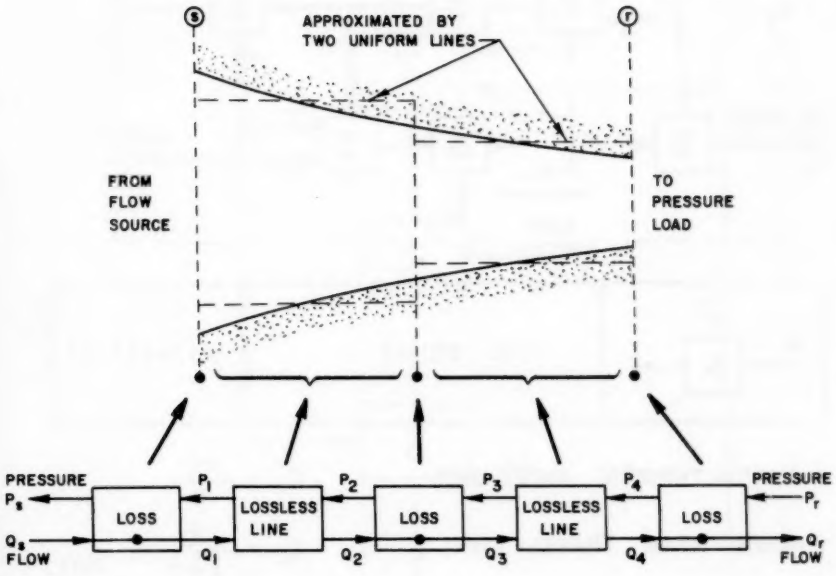
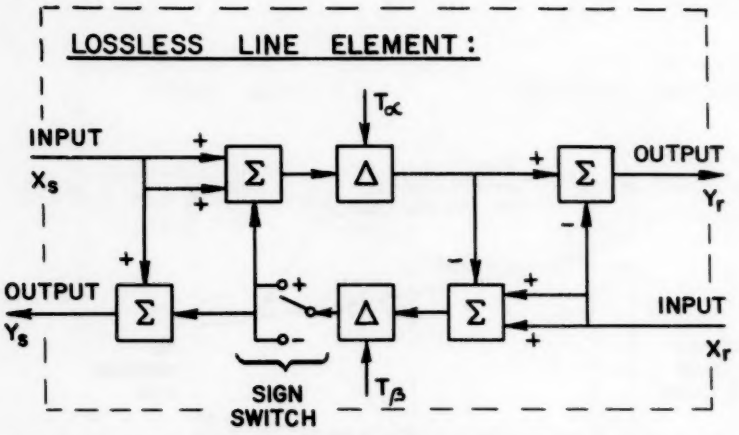
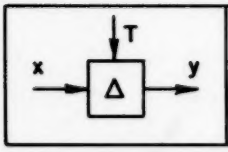


Figure 3: PIPELINE of VARIABLE CROSS SECTION





TIME DELAY

$y(t) = x(t-T)$

CHARACTERISTIC IMPEDANCE : $Z_c = \frac{\rho a}{A}$

DOWNSTREAM TRAVEL TIME : $T_\alpha = \frac{\ell}{a+\bar{U}}$

UPSTREAM TRAVEL TIME : $T_\beta = \frac{\ell}{a-\bar{U}}$

	CONFIGURATION		SIGN SWITCH	VARIABLES			
	SENDING END	RECEIVING END		INPUTS		OUTPUTS	
				X_s	X_r	Y_s	Y_r
I	IMPEDANCE	IMPEDANCE	−	P_s	P_r	Z_cQ_s	Z_cQ_r
II	IMPEDANCE	ADMITTANCE	+	P_s	Z_cQ_r	Z_cQ_s	P_r
III	ADMITTANCE	IMPEDANCE	+	Z_cQ_s	P_r	P_s	Z_cQ_r
IV	ADMITTANCE	ADMITTANCE	−	Z_cQ_s	Z_cQ_r	P_s	P_r

Figure 4: COMPUTOR MODEL of LINE

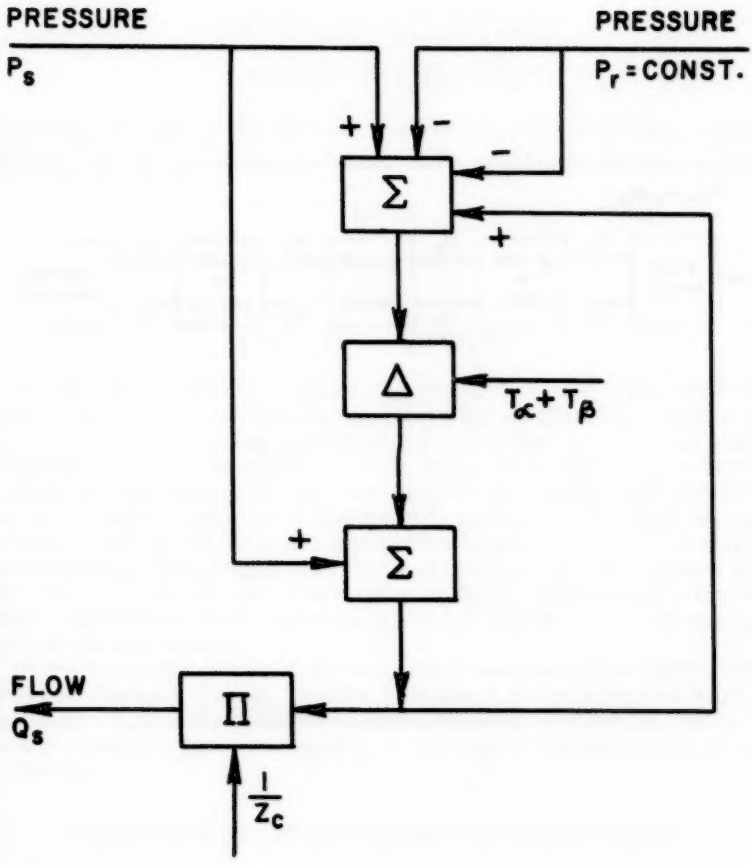


Figure 5: SENDING END IMPEDANCE

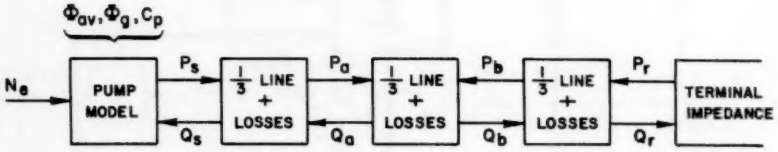


Figure 6: COMPUTOR MODEL of PUMPING SYSTEM

DIVISION ACTIVITIES

PIPELINE DIVISION

Proceedings of the American Society of Civil Engineers

NEWS

September, 1957

EXECUTIVE COMMITTEE

William T. Ivey has been appointed by the ASCE Board of Direction as a member of the Executive Committee of the Pipeline Division, effective October 1957 with term running to October 1961. Bill Ivey has been chairman of the Fluid Dynamics Committee. He will replace S. E. "Al" Huey whose term of office with the Executive Committee expires in October. "Al" Huey was one of the original members of the initial Committee on Pipelines organized in October 1953 under the frame-work of the Construction Division and assisted in getting Board approval in October 1956 for our new Pipeline Division. "Al" will become one of our Advisory Group members after October and we will continue to get his excellent advice and whole-hearted assistance with our division affairs.

During a recent meeting of the Research Committee of the ASCE, Mr. Elmer K. Timby of Howard, Needles, Tammen & Bergendoff, New York, was appointed to advise our Executive Committee on the various aspects of the research program for us to share in the research responsibilities of the profession.

PLANS FOR FUTURE PROGRAMS PROCEEDING RAPIDLY

Preliminary details for two conventions in 1958, each with a luncheon meeting, three or more half-day technical sessions, and a field trip, have been reported by Program Chairman R. E. Kling.

Chicago, Illinois, Sherman Hotel, Feb. 24-26, 1958

Commissioner William R. Connole of the Federal Power Commission will be the speaker at the convention luncheon being sponsored by the Pipeline Division on Monday, Feb. 24.

Joint sessions with the Highway and the Surveying & Mapping divisions are scheduled for Monday morning, with each division furnishing a speaker on a subject of interest to our pipeline group. Our pipeline speaker for the joint session with the Highway division will be C. D. Richardson, Asst.

Note: No. 1957-17 is part of the copyrighted Journal of the Pipeline Division of the American Society of Civil Engineers, Vol. 83, PL 3, September, 1957.

Superintendent of Pipelines, Transcontinental Gas of Houston, on the subject of gas pipeline relocation, casing and lowering jobs occasioned by highway construction. A speaker on techniques and standards for Pipeline location, surveying and mapping compared with those for highways and other industries is being arranged for the joint session with the Surveying & Mapping division.

The Monday afternoon technical session will tentatively include A. G. Barkow, Supt. of Inspection, Natural Gas Pipeline Co. of America, Chicago on "Pipeline Field Welding and Quality Control Methods," R. F. Bukacek, Dept. of Chemical Engineering, Illinois Institute of Technology, Chicago, on "Fluid Friction in Pipelines," and J. N. White, Panhandle Eastern Pipeline, Kansas City, on "Procedures for Testing Pipeline Efficiency."

A field trip to underground storage facilities and 36" pipeline construction activities in the vicinity of Chicago is being arranged for Tuesday, Feb. 25.

On Wednesday morning, prior to the general convention welcome session, a brief meeting of the Pipeline Division members will be held for announcements of future plans. The technical session on Wednesday afternoon will conclude the Pipeline Division program. Final details and complete list of speakers will be announced at a later date.

Dale C. Johnson is assisting in making all local arrangements.

Technical committee chairmen are expected to nominate speakers for completion of the Chicago program. Those not heard from should communicate with Program Chairman Kling as soon as possible. Deadline for final arrangements is in October and papers are to be submitted by the individual authors in January, 1958.

Portland, Oregon, Multonomah Hotel, June 23-27, 1958

This program, with 12 to 15 papers, will high-light recent and future pipeline transportation and distribution developments, particularly in the Pacific Northwest, of (1) oil, (2) products, (3) natural gas, (4) gilsonite slurry and other solids, and (5) water pipelines. Technical committee chairmen will be followed up by Sessions Programs for their reports of recommended speakers and subjects which are needed not later than October 1957.

Other Programs

Fred C. Culpepper of the Executive Committee has accepted the responsibility and duties of Co-ordinator for Programs to provide long-range planning and continuity by setting general themes for each meeting and to assist Session Program committee members when needed. All Advisory Group members are subject to call for help by the Co-ordinator. Future meetings now being considered are New York in Oct. 1958, Los Angeles in Feb. 1959, Cleveland in May 1959, Washington, D. C. in Oct. 1959, New Orleans in March 1960, Reno, Nevada, in June 1960, Boston in Oct. 1960, and Phoenix, Ariz., in April 1961.

Chairman Kling, in preparing the individual programs, has all chairmen of committees as ex-officio members of his Sessions Program Committee. D. E. Adams, sub-committee Chairman of the Film Library, is preparing his first listing to be mailed soon to all Student Chapters and Local Sections.

PUBLIC RELATIONS

Chairman Don Taylor prepared a letter which was mailed by Headquarters

in June to officials of leading pipeline companies and other associated industries, calling attention to the broad objectives of the Society and the Pipeline Division. A copy of the June Journal was enclosed as an example of one of the results of our efforts. This letter should be helpful for individual members to obtain effective encouragement from the management of their employer companies for their committee work in our newly-organized division and should stimulate greater participation in our activities.

PUBLICATIONS

Chairman Herb Smallwood left in June for a year or so with Technical Cooperation Mission at Howrah, West Bengal, India. His organizational work for the Publications Committee, editing and processing papers of the Jackson meeting and the back-log of other meeting papers, has been invaluable and his enthusiastic help is greatly missed. His replacement as Chairman is being sought.

Our first Pipeline Division Journal was published as of March and the second in June. Members are reminded that they are permitted to enroll in two technical divisions and receive automatically all publications of each and, in addition, 100 other different papers during the fiscal year. Headquarters mailed form letters in May to all committee chairmen to circularize their committee members to insure their official affiliation with our Pipeline Division. If you did not receive a copy of this form letter from your chairman, use the coupon in the monthly issues of "Civil Engineering" so that Headquarters can add your name to the mailing list of the Journal. Please advise non-members that they can purchase a copy of the Journal for $3.00 and individual papers at 50¢ per copy.

All members are urged to consider contributing to the technical work of the division by preparing unsolicited papers or discussions. Any committee member will be glad to hear from possible contributors to relay this information to the Publications Committee or the Secretary.

As requested by several members, listed below are papers and talks which have been presented at Pipeline meetings. Numbered papers can be obtained from Headquarters.

Midland, Texas, Meeting - April 9-10, 1954

"Scope of Pipeline Transportation in the U. S.," E. V. Hunt, Ebasco Services, New York (Transactions Paper # 2833).

"Revised ASA Code of Pressure Piping" (talk), W. H. Davidson, Transcontinental Gas Pipe Line, Houston.

"Use of Photogrammetry in Pipeline Construction," John H. Mitchell, Lockwood, Kessler & Bartlett, Great Neck, N. Y.

New York Meeting - Oct. 20-21, 1954

"Construction of Lakehead Pipeline and the Crossing of Mackinac Straits," (talk with sound-movie), S. D. Bechtel, Jr., Bechtel Corp., San Francisco.

"The Pipeline Carries the Punch," Maj. Gen. S. D. Sturgis, Chief of Engineers, Washington ("Civil Engineering" Dec. 1954).

"Competition Brings Economics to the Fore in Gas Pipeline Transmission," W. B. Poor, Ford, Bacon & Davis, N. Y. ("Civil Engineering" Nov. 1954).

"Economics of Pipeline Financing," Chas. J. Hodge, partner Glore, Forgan & Co., New York (Proc. Paper # 855).

San Diego Meeting - Feb. 9, 1955

"Design and Construction of P.G.&E.'s Super-Inch Line," P. E. Reynolds, Pacific Gas & Electric, San Francisco.

St. Louis Meeting - June 16-17, 1955

"Stresses in Pressure Pipelines and Protective Casing Pipes," Prof. M. G. Spangler, Iowa State College (Proc. Paper # 1054).
"The Pacific Northwest Pipeline Project," R. R. Herring, Pacific Northwest Pipeline Corp., Houston.
"Defense Pipelines in Spain," Rear Adminal John R. Perry CEC USN, Chief of Bureau of Yards and Docks, Washington.

Dallas Meeting - Feb. 15-17, 1956

"Pipelines - A Field for Civil Engineers," S. D. Bechtel, Jr., Bechtel Corp. San Francisco ("Civil Engineering" June 1956).
"Latest Developments in Offshore Pipeline Construction," Don M. Taylor, Gulf Coast Editor, "The Petroleum Engineer," Houston.
"Submarine Pipeline Construction" (talk with sound-movie), Sammy V. Collins, Port Lavaca, Texas.
"Route Surveys for Offshore Pipelines," Clyde Aldridge, Magnolia Pipe Line Co., Dallas (Proc. Paper in Sept. Journal).
"Pipelining is Engineered Design, Construction, Maintenance and Operation," Rear Admiral L. B. Combs CEC USN (Ret), Rensselaer Polytechnic, Troy, N. Y.
"Application of a Magnetic Drum Electronic Computer to Pipeline Design," Harold E. Thomas, El Paso Natural Gas, El Paso, Texas.
"Photogrammetry in Pipeline Engineering," Don H. Cude, Jack Ammann Photogrammetric Engineers, Inc., San Antonio.
"Underground Storage of Gas in Relation to Pipeline Operations," John P. Viglini, Lone Star Gas, Dallas.
"Maintaining Line Efficiency of Natural Gas Pipelines by Liquid Removal," A. W. Rifenburgh, Mississippi River Fuel Corp., St. Louis.

Pittsburgh Meeting - Oct. 14-17, 1956

"Organization and Administration of a Cooperative Corrosion Committee," C. A. Erickson, Peoples Natural Gas, Pittsburgh.
"Design and Strength of Welded Pipeline Branch Connections," E. C. Rodabaugh and H. H. George, Tube Turns, Louisville, Kentucky (Proc. Paper # 1193, in March Journal).
"High Pressure Steam Main Under New York City Streets," J. C. Fisher, Consolidated Edison, N. Y. (Proc. Paper # 1279 in June Journal).
"Right-of-Way Problems as They Affect the Engineer," F. A. Smith, Ford, Bacon & Davis, New York.
"Pipe Mill Operations," W. L. Fader, National Tube, McKeesport, Pa.
"New Developments in Pipeline Steels," A. B. Wilder, National Tube, Pittsburgh.

Jackson, Mississippi, Meeting - Feb. 17-19, 1957

"Flow of Natural Gas in Pipelines," W. T. Ivey and J. H. Dorough, Southern Natural Gas, Birmingham (Proc. Paper # 1194, in March Journal).

"Prediction of Surge Pressures in Oil Pipelines," R. D. Kersten, Carter Oil, Tulsa, and E. J. Waller, Okla. A&M (Proc. Paper # 1195, in March Journal).

"Secondary Stresses in Large-Diameter Pipelines," Geo. M. McClure, Battelle Memorial Institute, Columbus (Proc. Paper # 1280, in June Journal).

"Pipeline River Crossings," Leo M. Odom, Baton Rouge (Proc. Paper # 1281, in June Journal).

"Hydrostatic Testing of Pipelines," Leon E. Brooks, Williams Pressure Service, Shreveport (Proc. Paper, in Sept. Journal).

"Arabian Pipelines," Geo. D. Hartley, Arabian American Oil, Saudi Arabia ("Civil Engineering" June 1957).

"Missouri River Crossing at Plattsmouth, Nebraska" (commentaries with sound-movie), C. A. McReynolds, Northern Natural Gas, Omaha, A. C. Van Tassel, Pittsburgh-Des Moines Steel, Dallas, and Wilder Kenan, Matthews & Kenan, San Antonio.

Additional

"Pipelines - a Major American Industry," E. V. Hunt, Alberta Gas Trunkline, Calgary ("Civil Engineering" October 1955).

ACTIVITIES OF TECHNICAL COMMITTEES

Committee chairmen are assisting Sessions Programs by nominating authors and subjects for meeting papers, and collaborating with Publications by naming members to review and edit technical papers. The 1957-1958 budget request provides for a task group meeting for each of the technical committees, which meetings will be held at central points as called for by the respective chairmen. Chairmen are urged to take advantage of the budget provisions for their committees.

Fluid Dynamics

Chairman Bill Ivey is providing a forum in fields not previously reached by other Society divisions with subjects on (1) flow of gases in pipelines with related problems of gravity, friction coefficient, transmission factor, compressibility, deviation, and hydrate formation and liquids transmission, (2) flow of oils, distillate, products, and crude with related problems of the hydro-mechanics of oil pipelines, gravity, pressure surge, and minimum temperature at which oil can be moved, (3) dual flow of gases and liquids in a common pipeline with related problems of bubble, plug, slug, wavy or stratified flow, and the corresponding line efficiencies of such two-phase lines, and (4) problems inherent in the transmission of solids in pipelines. Papers are being solicited on transmission of viscous fluids, utilizing the fluid-conveying pipe as an electrical conductor for the generation of controlled heat increments. Also, a paper on evaluating pressure losses in gas pipelines based on liquid flow experience. The problems, pressures, and distances on transportation of gilsonite and other slurries are also slated for future papers.

Pipeline Location, Surveying & Mapping

Chairman Howard Hayes has been sending out questionnaires to about 100 crude, products, gas and water pipeline companies on existing policies relative to pipeline location—road crossing angles; clearances for crossings of other pipelines and cables; reasons for depth of cover, extra cover or use of weights; spacing of loop lines in relation to the initial line at critical points; influence of future looping and right-of-way cost, mineable deposits, mineral rights; influence of swamps, peat bogs, and inaccessible areas; and the design and location of gas pipelines in accordance with the ASA B31.1.8 Code of Pressure Piping as to population density and distances to human-occupancy buildings. Results of certain questions will be submitted to American Right-of-Way Association representatives and to members of the Pipeline Contractors Association for additional queries. A final report will be made at one of the Pipeline meetings and for the Pipeline Journal.

J. F. Schaffer of El Paso Natural Gas and J. C. Faulkner of Texas Eastern Transmission will serve with members of the Surveying & Mapping Division on a joint project to form a group to prepare a manual on Pipeline Location, Surveying & Mapping.

Pipeline Crossings of Railroads and Highways

Chairman Joe E. Thompson reports that the organization of his committee of thirty-two members was completed at a meeting in Chicago on June 20, 1957. In order to complete the tentative specification to be submitted to the ASA for adoption as a standard code for pipeline crossings under and parallel to railroads and highways, task groups have been designated to write a specific portion of the specification. A preliminary draft will be submitted at the meetings this fall of the following organizations: (1) American Gas Association, (2) American Railway Engineering Association, (3) Southern Gas Association, (4) American Association of State Highway Officials, (5) American Petroleum Institute, (6) American Standards Association—Sub-committee 8, and (7) Highway Division of the ASCE.

Pipeline Design, Specifications & Operating Standards

Chairman Larry Shea has circularized his committee members for opinions as to the organization of this all-inclusive committee by a questionnaire on proposed activities, type of organization, and personal information for proper assignment to committee work. Due to the heavy construction program this summer being experienced by most of his committee members, two organizational meetings are being scheduled about October to be followed by about six meetings at various central locations for specific task groups.

Pumping and Compressor Stations

Chairman Fred Culvern is now with Williams Brothers Co., Tulsa, Oklahoma. No report has been received from him at this writing on his organizational plans and scheduling of papers.

Storage of Pipeline Fluids

Chairman Arthur Everham has been discussing his organizational problems with several members. Volunteers for his committee work are requested to contact him direct.

MEMBERSHIP

At the October 1953 meeting in New York, 6 members initiated a Pipeline

Committee under the Construction Division. The Board authorized the present Pipeline Division as a 14th division of the Society at the Pittsburgh meeting in October 1956 with the following purpose:

> "To advance and correlate scientific knowledge and promote and coordinate economic development and construction of engineering projects in connection with the transmission of liquids, gases or solids by means of pipelines and as it pertains, in particular, to the science of civil engineering in the fields of surveying and line location, design, construction and operations, and to promote and further the mutual utilization of the established codes for pressure piping as between pipeline, highway and railroad groups and public authorities."

Our committee members totaled 90 at the 1956 meeting. We now have 125 volunteer committee workers and about 150 other members affiliated with the division. The volunteer committee workers are as follows:

Executive Committee

Chairman E. V. Hunt, Alberta Gas Trunkline Co., 320 9th Ave. West, Calgary, Alberta (1958); Vice Chairman A. E. Poole, Hallen Construction Co., 4270 Austin Blvd., Island Park, N. Y. (1959); S. E. Huey, Heninger Bldg., Monroe, La. (1957) being replaced by W. T. Ivey, Southern Natural Gas, Box 2563, Birmingham, Ala. (1961), F. C. Culpepper, Jr., Ford, Bacon & Davis, Inc., Box 370, Moundsville, W. Va. (1960); Secretary J. B. Spangler, Transcontinental Gas Pipe Line, P. O. Box 296, Houston, Tex.; L. A. Elsener, Board Contact Member, V. P., Chicago Bridge & Iron Co., 100 Bush St., San Francisco, Calif.; E. K. Timby, Research Committee Contact Member, Howard, Needles, Tammen & Bergendorff, 99 Church St., New York.

Advisory

S. D. Bechtel, Bechtel Corp., San Francisco; Rear Admiral L. B. Combs, Rensselaer Polytechnic Institute, Troy, N. Y.; C. M. Davis, Fort Worth, Tex.; B. D. Goodrich, Texas Eastern Transmission, Shreveport; H. H. Hall, Bechtel Corp., San Francisco; W. B. Poor, Ford, Bacon & Davis, N. Y.; W. W. Studdert, Midland, Tex.

Publications

D. R. Jenkins, Battelle, Memorial Inst., Columbus, Ohio; R. L. Schneider, Owens-Corning Fiberglas, Tulsa; Adam Sommer, Alco Products, Dunkirk, N. Y. (Replacement for Chairman H. A. Smallwood, now in India, being sought).

Session Programs

Chairman R. E. Kling, Mississippi River Feul Corp., 407 North 8th, St. Louis, Mo.; D. E. Adams, Hallen Construction, Island Park, N. Y. (Film Library); John Duchkar, Ford, Bacon & Davis Constr. Corp., Alliance, Ohio; Dale C. Johnson, Natural Gas Pipeline Co. of America, Chicago (Chicago convention); M. G. Higman, Jackson, Miss.; M. B. Hood, Pittsburgh Testing Laboratory, Springdale, Penn.; J. J. Koy, United Gas Pipe Line, San Antonio; A. Switzer, Jackson, Miss.

Membership

Chairman Leo M. Odom, Box 267, Baton Rouge, La.; G. E. Arnold, Philadelphia Water Dept., Philadelphia; W. E. Cary, Fish Eng. Corp., Houston; S. H. Fistedis, Argonne National Laboratory, Lamont, Ill.; J. M. Pimenta,

Hazelet & Erdal, Chicago; W. E. Rudolph, Chile Exploration Co., Chuquicamata, Chile; J. F. Schaffer, El Paso Natural Gas, El Paso.

Public Relations

Chairman Don M. Taylor, Gulf Coast Editor, "The Petroleum Engineer," 2370 Rice Blvd. Room 110, Houston, Tex.; R. C. Hughes, Pipeline Technologists, Houston; R. C. Newsome, Trunkline Gas, Houston; Elton Sterrett, Eng. Editor, "Pipe Line News," Houston; A. T. Surber, Trunkline Gas, Houston.

Cooperation With Local Sections

Chairman R. R. Crawford, Bechtel Corp., 209 H St., San Rafael, Calif.

Fluid Dynamics

Chairman W. T. Ivey, Southern Natural Gas, Box 2563, Birmingham, Ala.; M. D. Altfillisch, Norwood Controls, Norwood, Mass.; R. B. Banks, Northwestern Univ., Evanston, Ill.; J. H. Dorough, Southern Natural Gas, Birmingham, Ala.; T. L. Guerry, Pipeline Technologists, Houston; F. E. Hangs, Pipeline Technologists, Houston; E. L. Harrington, Texas A & M, College Station, Tex.; G. D. Hartley, Arabian American Oil Co., Box 596, Abqaiq, Saudi Arabia; R. D. Kersten, Carter Oil, Tulsa; D. T. King, Southern Natural Gas, Birmingham; W. L. Moore, Univ. of Texas, Austin; A. C. Purdue, Fluid Systems, Inc., New Haven, Conn.; E. J. Waller, Okla. A & M, Stillwater, Okla.; H. M. Wyatt, Okla. A & M, Stillwater, Okla.

Pipeline Location, Surveying & Mapping

Chairman H. M. Hayes, Ford, Bacon & Davis, Box 1762, Monroe, La.; T. L. Atherton, Calif. Dept. of Water Resources, Box 1079, Sacramento, Calif.; W. G. Birkhead, United Gas Pipe Line, Beaumont; E. V. Browne, Long Island Lighting, New York; R. Falk, El Paso Natural Gas, El Paso; J. C. Faulkner, Texas Eastern Transmission, Shreveport (Task Group - Manual); E. L. Harrington, Texas A & M, College Station, Tex.; W. F. Howard, El Paso Natural Gas, El Paso; L. M. Kingsland, Transcontinental Gas Pipe Line, Houston; F. W. Lunsmann, Natural Gas Pipeline Co. of America, Chicago; Banks McLaurin, Atlantic Refining Co., Dallas; J. F. Schaffer, El Paso Natural Gas, El Paso (Task Group - Manual); V. B. Speaker, Southern Natural Gas, Birmingham; Dan Williamson, Transcontinental Gas Pipe Line, Houston.

Pipeline Crossings of Railroads & Highways

Chairman J. E. Thompson, Natural Gas Pipeline Co. of America, 122 S. Michigan, Chicago, Ill.; Vice Chairman G. D. Mock (rep. ASA B.31.8), Washington Gas Light, Washington, D. C.

Advisory Group

S. E. Ridge, Bureau of Public Roads, Washington, D. C.; C. T. Kallina, Federal Power Commission, Washington, D. C.; S. A. Wilson, Bethlehem Steel, Bethlehem, Pa.; A. B. Wilder, National Tube, U. S. Steel Corp., Pittsburgh, Pa.

Committee Engineering Assistants

R. F. Altmeyer and LeRoy F. Busa, Natural Gas Pipeline Co. of America, Chicago, Ill.

Sub-committee - Pipeline Crossings of Railways (Oil, Gas & Products)

Chairman E. A. Slade (rep. API, Okan Pipeline Co., Tulsa, Okla.; Vice Chairman K. W. Schoeneberg (rep. AREA Com. # 1), St. Louis- San Francisco Railway, Fort Smith, Ark. Task Group - Distribution:

Chairman E. F. Trunk (rep. AGA), Laclede Gas Co., St. Louis, Mo.; H. C. Missimer, Philadelphia Gas Works, Philadelphia, Pa.; K. L. DeBlois, New York Central Railroad, Chicago, Ill.; J. W. Purdy (rep. AREA Com.#1), B & O R.R., Cincinnati, Ohio. Task Group - Transmission: Chairman W. B. Haas (rep. SGA), Northern Natural Gas, Omaha, Neb.; A. J. Wegmann (rep. AREA Com. #1), B & O R.R. Baltimore, Md.; Morgan Martin (rep. API), Gulf Refining, Houston, Tex.; C. Neufeld (rep. AREA Com. #15), Canadian Pacific Railway, Montreal, Quebec; L. L. Elder (rep. AGA), Columbia Gas System Service Corp., Columbus, Ohio.

Sub-committee - Pipeline Crossings of Highways (Oil, Gas & Products)
Chairman R. Robinson Rowe, California State Division of Highways, Sacramento, Calif.; Vice Chairman J. F. Schaffer (rep. AGA), El Paso Natural Gas, El Paso, Tex. Task Group - Distribution: Chairman J. C. Fisher, Consolidated Edison Gas Co. of New York, New York, N. Y.; B. F. Worley (rep. AGA), United Gas Corp., Shreveport, La.; E. H. Jones, Commonwealth of Pennsylvania Dept. of Highways, Harrisburg, Pa.; W. T. Corley (rep. API), Interstate Oil Pipe Line Co., Shreveport, La.; H. A. Franklin, Iowa State Commerce Commission, Des Moines, Iowa. Task Group - Transmission: Chairman D. A. Roach (rep. API), Phillips Petroleum Co., Bartlesville, Okla.; A. H. Stone, Joseph K. Knoerle & Assoc. consultants for Illinois Toll Highway Commission, Chicago, Ill.; E. F. Kauffman, Oklahoma Dept. of Highways, Oklahoma City, Okla.; O. W. Clark (rep. ASA B31.8), Southern Natural Gas Co., Birmingham, Ala.; J. F. Dear, Sun Pipe Line Co., Beaumont, Texas.

Sub-committee - Pipelines (Misc.) Highways & Railroads
Chairman John G. Hendrickson, Jr., American Concrete Pressure Pipe Assn., Chicago, Ill.; Vice Chairman, J. W. Purdy (rep. AREA Com. #1), B & O R.R., Cincinnati, Ohio.

Pipeline Design, Specifications & Operating Standards
Chairman C. L. Shea, Products Pipe Lines, Shell Oil Co., 8500 N. Michigan Road, Indianapolis, Ind.; J. J. Ball, Texas Eastern Transmission, Shreveport, La.; J. L. Butler, Bureau of Construction, Board of Education, New York, N. Y.; Rex V. Campbell, American Louisiana Pipe Line, Detroit, Mich.; H. J. Chapton, Los Angeles Water System, Glendale, Calif.; S. M. Davidson, Thompson Pipe & Steel Co., Denver; C. W. E. Davies, Alco Products Inc., Dunkirk, N. Y.; R. E. Elberle, Walnut Creek, Calif.; Richard Garnjost, Midwest Products Div., Buckeye Pipe Line Co., Lima, Ohio; S. W. Gurasich, Sperry-Sun Well Surveying, Houston; J. G. Hendrickson, American Concrete Pressure Pipe Assn., Chicago; L. A. Hoffman, Birmingham, Ala.; R. C. Hughes, Pipeline Technologists, Houston; T. E. Hunt, Consumers Power Co., Detroit; D. R. Jenkins, Battelle Memorial Institute, Columbus, Ohio; H. H. List, Shell Pipeline Corp., Houston; R. D. McClintock, American Louisiana Pipe Line Co., Detroit; A. C. McLaughlin, American Oil Co., Long Beach, N. Y.; C. A. McReynolds, Northern Natural Gas, Omaha, Neb.; W. W. Offner, X-Ray Engineering International, San Francisco, Calif.; G. I. Perryman, Creole Petroleum, Tia Juana, Estado Zulia, Venezuela; J. W. Pierce, Eastern Municipal Water District, Hemet, Calif.; J. M. Pimenta, Hazelet & Erdal, Chicago; R. Salmon, Texas Petroleum Co., Bogota, Colombia; R. L. Schneider, Owens-Corning Fiberglas, Tulsa; M. J. Shelton, Calif. Dept. of

Water Resources, Sacramento, Calif.; H. A. Smallwood, Technical Cooperation Mission, Howrah, West Bengal, India; Adam Sommer, Alco Products Inc., Dunkirk, N. Y.; F. J. Stastny, Texas Eastern Transmission, Shreveport; W. T. Theis, Internal Pipeline Maintenance, Odessa, Tex.; J. F. Thomson, Gray Concrete Pipe, Baltimore, Md.; A. C. Van Tassell, Pittsburgh-Des Moines Steel, Dallas; S. A. Wilson, Bethlehem Steel, Bethlehem, Pa.

Pumping & Compressor Stations

Chairman F. E. Culvern, Williams Brothers Co., National Bank of Tulsa Bldg., Tulsa, Okla.; E. W. Beimes, D. P. W. Office - Pearl Harbor, Honolulu; W. H. Koehler, Danville, Va.; Rex V. Campbell, American Louisiana Pipe Line, Detroit; H. W. Shubring, Clark Bros. Co., Olean, N. Y.; J. R. Teerink, Calif. Dept. of Water Resources, Sacramento, Calif.

Storage of Pipeline Fluids

Chairman A. T. Everham, Midwestern Contractors, 130 W. Liberty Drive, Wheaton, Ill.; I. E. Boberg, Chicago Bridge & Iron Co., Chicago; R. E. Kling, Mississippi River Fuel Corp., St. Louis, Mo.

****

Your present Editor is the Secretary of the Executive Committee. Comments, suggestions, and any news items of interest will be appreciated from all members. Deadline date for the next Newsletter is October 31, please.

J. B. Spangler, Newsletter Editor
c/o Transcontinental Gas Pipe Line Co
P.O. Box 296, Houston 1, Texas

PROCEEDINGS PAPERS

The technical papers published in the past year are identified by number below. Technical-division sponsorship is indicated by an abbreviation at the end of each Paper Number, the symbols referring to: Air Transport (AT), City Planning (CP), Construction (CO), Engineering Mechanics (EM), Highway (HW), Hydraulics (HY), Irrigation and Drainage (IR), Pipeline (PL), Power (PO), Sanitary Engineering (SA), Soil Mechanics and Foundations (SM), Structural (ST), Surveying and Mapping (SU), and Waterways and Harbors (WW), divisions. Papers sponsored by the Board of Direction are identified by the symbols (BD). For titles and order coupons, refer to the appropriate issue of "Civil Engineering." Beginning with Volume 82 (January 1956) papers were published in Journals of the various Technical Divisions. To locate papers in the Journals, the symbols after the paper numbers are followed by a numeral designating the issue of a particular Journal in which the paper appeared. For example, Paper 1113 is identified as 1113 (HY6) which indicates that the paper is contained in the sixth issue of the Journal of the Hydraulics Division during 1956.

VOLUME 82 (1956)

SEPTEMBER: 1054(ST5), 1055(ST5), 1056(ST5), 1057(ST5), 1058(ST5), 1059(WW4), 1060(WW4), 1061(WW4), 1062(WW4), 1063(WW4), 1064(SU2), 1065(SU2), 1066(SU2)[c], 1067(ST5)[c], 1068 (WW4)[c], 1069(WW4).

OCTOBER: 1070(EM4), 1071(EM4), 1072(EM4), 1073(EM4), 1074(HW3), 1075(HW3), 1076(HW3), 1077(HY5), 1078(SA5), 1079(SM4), 1080(SM4), 1081(SM4), 1082(HY5), 1083(SA5), 1084(SA5), 1085(SA5), 1086(PO5), 1087(SA5), 1088(SA5), 1089(SA5), 1090(HW3), 1091(EM4)[c], 1092 (HY5)[c], 1093(HW3)[c], 1094(PO5)[c], 1095(SM4)[c].

NOVEMBER: 1096(ST6), 1097(ST6), 1098(ST6), 1099(ST6), 1100(ST6), 1101(ST6), 1102(IR3), 1103 (IR3), 1104(IR3), 1105(IR3), 1106(ST6), 1107(ST6), 1108(ST6), 1109(AT3), 1110(AT3)[c], 1111(IR3)[c]; 1112(ST6)[c].

DECEMBER: 1113(HY6), 1114(HY6), 1115(SA6), 1116(SA6), 1117(SU3), 1118(SU3), 1119(WW5), 1120(WW5), 1121(WW5), 1122(WW5), 1123(WW5), 1124(WW5)[c], 1125(BD1)[c], 1126(SA6), 1127 (SA6), 1128(WW5), 1129(SA6)[c], 1130(PO6)[c], 1131(HY6)[c], 1132(PO6), 1133(PO6), 1134(PO6), 1135(BD1).

VOLUME 83 (1957)

JANUARY: 1136(CP1), 1137(CP1), 1138(EM1), 1139(EM1), 1140(EM1), 1141(EM1), 1142(SM1), 1143(SM1), 1144(SM1), 1145(SM1), 1146(ST1), 1147(ST1), 1148(ST1), 1149(ST1), 1150(ST1), 1151(ST1), 1152(CP1)[c], 1153(HW1), 1154(EM1)[c], 1155(SM1)[c], 1156(ST1)[c], 1157(EM1), 1158 (EM1), 1159(SM1), 1160(SM1), 1161(SM1).

FEBRUARY: 1162(HY1), 1163(HY1), 1164(HY1), 1165(HY1), 1166(HY1), 1167(HY1), 1168(SA1), 1169(SA1), 1170(SA1), 1171(SA1), 1172(SA1), 1173(SA1), 1174(SA1), 1175(SA1), 1176(SA1), 1177(HY1)[c], 1178(SA1), 1179(SA1), 1180(SA1), 1181(SA1), 1182(PO1), 1183(PO1), 1184(PO1), 1185(PO1)[c].

MARCH: 1186(ST2), 1187(ST2), 1188(ST2), 1189(ST2), 1190(ST2), 1191(ST2), 1192(ST2)[c], 1193 (PL1), 1194(PL1), 1195(PL1).

APRIL: 1196(EM2), 1197(HY2), 1198(HY2), 1199(HY2), 1200(HY2), 1201(HY2), 1202(HY2), 1203 (SA2), 1204(SM2), 1205(SM2), 1206(SM2), 1207(SM2), 1208(WW1), 1209(WW1), 1210(WW1), 1211(WW1), 1212(EM2), 1213(EM2), 1214(EM2), 1215(PO2), 1216(PO2), 1217(PO2), 1218 (SA2), 1219(SA2), 1220(SA2), 1221(SA2), 1222(SA2), 1223(SA2), 1224(SA2), 1225(PO)[c], 1226 (WW1)[c], 1227(SA2)[c], 1228(SM2)[c], 1229(EM2)[c], 1230(HY2)[c].

MAY: 1231(ST3), 1232(ST3), 1233(ST3), 1234(ST3), 1235(IR1), 1236(IR1), 1237(WW2), 1238(WW2), 1239(WW2), 1240(WW2), 1241(WW2), 1242(WW2), 1243(WW2), 1244(HW2), 1245(HW2), 1246 (HW2), 1247(HW2), 1248(WW2), 1249(HW2), 1250(HW2), 1251(WW2), 1252(WW2), 1253(IR1), 1254(ST3), 1255(ST3), 1256(HW2), 1257(IR1)[c], 1258(HW2)[c], 1259(ST3)[c].

JUNE: 1260(HY3), 1261(HY3), 1262(HY3), 1263(HY3), 1264(HY3), 1265(HY3), 1266(HY3), 1267 (PO3), 1268(PO3), 1269(SA3), 1270(SA3), 1271(SA3), 1272(SA3), 1273(SA3), 1274(SA3), 1275 (SA3), 1276(SA3), 1277(HY3), 1278(HY3), 1279(PL2), 1280(PL2), 1281(PL2), 1282(SA3), 1283 (HY3)[c],1284(PO3), 1285(PO3), 1286(PO3), 1287(PO3)[c], 1288(SA3)[c].

JULY: 1289(SM3), 1290(EM3), 1291(EM3), 1292(EM3), 1293(EM3), 1294(HW3), 1295(HW3), 1296(HW3), 1297(HW3), 1298(HW3), 1299(SM3), 1300(SM3), 1301(SM3), 1302(ST4), 1303 (ST4), 1304(ST4), 1305(SU1), 1306(SU1), 1307(SU1), 1308(ST4), 1309(SM3), 1310(SU1)[c], 1311(EM3)[c], 1312(ST4), 1313(ST4), 1314(ST4), 1315(ST4), 1316(ST4), 1317(ST4), 1318 (ST4), 1319(SM3)[c], 1320(ST4), 1321(ST4), 1322(EM3), 1323(AT1), 1324(AT1), 1325(AT1), 1326(AT1), 1327(AT1), 1328(AT1)[c], 1329(ST4)[c].

AUGUST: 1330(HY4), 1331(HY4), 1332(HY4), 1333(SA4), 1334(SA4), 1335(SA4), 1336(SA4), 1337(SA4), 1338(SA4), 1339(CO1) 1340(CO1), 1341(CO1), 1342(CO1), 1343(CO1), 1344(PO4), 1345(HY4), 1346(PO4)[c], 1347(BD1), 1348(HY4)[c], 1349(SA4)[c], 1350(PO4), 1351(PO4).

SEPTEMBER: 1352(IR2), 1353(ST5), 1354(ST5), 1355(ST5), 1356(ST5), 1357(ST5), 1358(ST5), 1359(IR2), 1360(IR2), 1361(ST5), 1362(IR2), 1363(IR2), 1364(IR2), 1365(WW3), 1366(WW3), 1367(WW3), 1368(WW3), 1369(WW3), 1370(WW3), 1371(HW4), 1372(HW4), 1373(HW4), 1374(HW4), 1375(PL3), 1376(PL3), 1377(IR2)[c], 1378(HW4)[c], 1379(IR2), 1380(HW4), 1381(WW3)[c], 1382(ST5)[c], 1383(PL3)[c], 1384(IR2), 1385(HW4), 1386(HW4).

c. Discussion of several papers, grouped by Divisions.

AMERICAN SOCIETY OF CIVIL ENGINEERS

OFFICERS FOR 1957

PRESIDENT

MASON GRAVES LOCKWOOD

VICE-PRESIDENTS

Term expires October, 1957:
FRANK A. MARSTON
GLENN W. HOLCOMB

Term expires October, 1958:
FRANCIS S. FRIEL
NORMAN R. MOORE

DIRECTORS

Term expires October, 1957:
JEWELL M. GARRELTS
FREDERICK H. PAULSON
GEORGE S. RICHARDSON
DON M. CORBETT
GRAHAM P. WILLOUGHBY
LAWRENCE A. ELSENER

Term expires October, 1958:
JOHN P. RILEY
CAREY H. BROWN
MASON C. PRICHARD
ROBERT H. SHERLOCK
R. ROBINSON ROWE
LOUIS E. RYDELL
CLARENCE L. ECKEL

Term expires October, 1959:
CLINTON D. HANOVER, Jr.
E. LELAND DURKEE
HOWARD F. PECKWORTH
FINLEY B. LAVERTY
WILLIAM J. HEDLEY
RANDLE B. ALEXANDER

PAST-PRESIDENTS

Members of the Board

WILLIAM R. GLIDDEN

ENOCH R. NEEDLES

EXECUTIVE SECRETARY
WILLIAM H. WISELY

TREASURER
CHARLES E. TROUT

ASSISTANT SECRETARY
E. LAWRENCE CHANDLER

ASSISTANT TREASURER
CARLTON S. PROCTOR

PROCEEDINGS OF THE SOCIETY

HAROLD T. LARSEN
Manager of Technical Publications

PAUL A. PARISI
Editor of Technical Publications

FRANCIS J. SCHNELLER, JR.
Assistant Editor of Technical Publications

COMMITTEE ON PUBLICATIONS

JEWELL M. GARRELTS, *Chairman*

HOWARD F. PECKWORTH, *Vice-Chairman*

E. LELAND DURKEE
MASON C. PRICHARD
R. ROBINSON ROWE
LOUIS E. RYDELL